Mathematical communication ability of students viewed from self-efficacy

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Abstract. This research aimed to describe mathematical communication ability of students viewed from self-efficacy. This research was descriptive qualitative research. Subjects in this research were students of grade eight SMP Negeri 1 Marioriawa Kabupaten Soppeng Sulawesi Selatan. The data were collected by a test, questionnaire, and interview. Data analysis techniques consisted of three steps, namely: data reduction, data display, and make conclusion. The result of data analysis showed that students with high self-efficacy could master all indicators of mathematical communication ability, namely: ability to identify and write information needed in solving problems by using notation, symbol, or mathematical term; ability to translate the essay or word problems into the picture or sketch and create mathematics models; ability to use precise mathematics concepts in solving the problem. Students with moderate self-efficacy could master two indicators, namely: ability to identify and write information needed in solving problem by using notation, symbol, or mathematical term; ability to translate the essay or word problem into the picture or sketch and create mathematics model. Students with low self-efficacy were only able to master indicator of ability to identify and write the information needed in solving problem by using notation, symbol, or mathematical term.

1. Introduction
Cockroft states that mathematics is an important knowledge because mathematics supports the development of other fields of knowledge. Another argument reveals that mathematics is an activity that can not be separated from human life [2,3]. Nevertheless, in mathematics there are several capabilities that need to be developed, i.e. one of them is the mathematical communication ability. Mathematical communication ability is one of aspect from five aspects in mathematics education curriculum in Indonesia which is important to develop for students [4]. Mathematical communication is important for students as it becomes a means to better understand the meaning of mathematical concept [5,6]. Mathematical communication is also one of factor that supports the improvement of other mathematics skill, such as students’ problem-solving skill and students' mathematical thinking skill [7, 8]. The importance of mathematical communication, often not in line with the condition of students in the classroom. Observation by Agustyaningrum [9] also showed that there was a problem with the students' mathematical communication ability. When the teacher asked a question, the
students were unable to give the correct reason for answering the question. In addition, when students are faced word problem, students are difficulty to translate it into the mathematics language or make mathematical model.

In mathematics, communication is defined as process of expressing and understanding mathematics ideas by orally, visually, and in writing using numbers, tables, diagrams, or words [10]. Mooney, et al [11] define that mathematical communication is way of students to express mathematics ideas and concepts using text, table, picture or symbol related to mathematics. Students restate a mathematics problem from a representation to another representation with purpose, they can find precise concept to solve the problem [12,13]. Based on the explanation above, it refers to mathematical communication in writing. Not only express idea or mathematics concept in various forms of mathematical expression (numbers, tables, diagrams, or mathematical symbols), but also mathematical communication in writing can be student's skill in solving mathematics problem [14].

Los Angeles Country Office of Education explains that mathematical communication is student's ability to reflect and clarify mathematics ideas, change problem to mathematics language using symbols, using reading, listening, interpreting, and evaluating mathematics ideas, and using mathematics idea to create conjectures and arguments [14]. Based on the opinion above, mathematical communication ability that will be described in this research is mathematical communication in writing consisted of three indicators i.e. (a) the ability to identify and rewrite the information needed to solve the mathematics problem by using notation, symbol or mathematics term; (b) the ability to translate mathematics problem or word problem into pictures or sketches and create mathematical model; (c) the ability to use precise mathematical concepts in solving mathematics problem.

On the other side, students' self-confidence in their ability is also needed to support their learning achievement, especially in mathematics [15,16]. Students' self-confidence in their abilities is called self-efficacy. Self-efficacy is students’ confidence in their ability to accomplish tasks [17,18]. In learning mathematics, self-efficacy is student's assessment of his ability to complete mathematics task or be able to successfully on other programs related to mathematics [19]. Therefore, self-efficacy is needed by students in learning mathematics [20].

Kitsantas, Cheema, and Ware in their research [21] reveal that, students with low self-efficacy tend to have low mathematics score and spend much time to accomplish mathematics task. Another research reveals that students with high self-efficacy tend to do great effort and they are not easy hopeless in accomplishing the task. Otherwise, students with low self-efficacy tend to doubt in their ability and they are easy hopeless when experiencing failure [22]. It is supported by other opinions that, students with high self-efficacy tend to be interested in working on problems with different difficult levels and when they faced to difficulties and mistakes, they will try again to accomplish it. Conversely, students with low self-efficacy tend to avoid in solving the problem, especially if the difficulty level is high [23].

According to Bandura, there are four sources of student’s self-efficacy, namely performance accomplishment, vicarious experience, verbal persuasion, and emotional arousal [24]. Performance accomplishment interpreted as self-efficacy students can grow based on the existence of the practice of individual success in solving the task. On the other hand, students’ self-efficacy can also grow with the experience of others (vicarious experience). Verbal persuasion means that the reaction and response of parents, teachers, or friends can affect students’ beliefs. But on the other hand negative comments from others can also decrease student self-efficacy. The last factor that influences the low level of atudent self-efficacy is the physiological (emotional arousal) reaction that arises as a feeling of stress, anxiety, fatigue, etc. Based on the above explanation, the purpose of this research is to notice and describe students' mathematical communication ability profile viewed from their self-efficacy.

2. Method
This research was descriptive qualitative research. This research was conducted at SMP Negeri 1 Marioriawa Soppeng regency South Sulawesi. Research subjects were eight grade on the circle material. The data were collected by three instruments i.e. (1) self-efficacy questionnaire consisted of 30 statements, (2) mathematical communication ability test consisted of three problems where each
problem contains three questions to measure each indicator of mathematical communication ability, and (3) interview guideline. Instrument validity in this research was content validity which was obtained from expert judgment. The data collection procedure began from distributing self-efficacy questionnaire and test of mathematical communication ability to the subject of research. Based on the data of self-efficacy questionnaire, students were divided into three groups according to the following criteria.

<table>
<thead>
<tr>
<th>Self-Efficacy Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>X &gt; 102</td>
<td>High self-efficacy</td>
</tr>
<tr>
<td>78 &lt; X ≤ 102</td>
<td>Moderate self-efficacy</td>
</tr>
<tr>
<td>X ≤ 78</td>
<td>Low self-efficacy</td>
</tr>
</tbody>
</table>

Then, data of self-efficacy and data of mathematical communication ability were analyzed by using correlation to notice significance relation both of them. The last, data of mathematical communication ability were analyzed by three stages i.e. (1) data reduction, (2) data display, and (3) make conclusion. The data of students' mathematical communication ability test result were also adjusted to the interview result from each group of students to make conclusion.

3. Result and Discussion
First, students were divided into groups based on their self-efficacy score. Data of self-efficacy questionnaire showed that of the forty-five students who completed the questionnaire, ten students had high self-efficacy, thirty students had moderate self-efficacy, and five students had low self-efficacy in learning mathematics. Meanwhile the correlation test result can be seen in table 2 below.

<table>
<thead>
<tr>
<th></th>
<th>SE</th>
<th>MCA</th>
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<tbody>
<tr>
<td>SE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pearson Correlation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td></td>
</tr>
</tbody>
</table>

Based on table 2 above can be seen that value of pearson correlation 0.564** > 0.5. It means that there is a strong correlation between SE (self-efficacy) and MCA (mathematical communication ability).

3.1. Student with High Self-Efficacy
Figure 1, 2, and 3 above show that students with high self-efficacy are able to complete all problems and questions of mathematical communication ability well. The picture above for part A's question indicates that student is able identify the information needed to complete three questions well. Also student rewrites all the informations by using mathematical symbols which is precise. This notices that representing a mathematical problem into another form such as a certain symbol allows students to find the precise concepts to solve the problem [12]. When interview, student could explain well the meaning of each symbol which he wrote. This shows that student understands the mean of the three questions. Based on the figure 1 and 2 above, it appears that the student translates the problem into the form of the picture or sketch after he rewrites the information needed to solve the problem. According to the Anderson's opinion that translating a problem occurs when student changes the information from one representation to another representation [13]. The reprensentation can be in the form of changing the information that the form of verbal (words) into images, etc. Based on answer number 1, the student is correct in using concept of arc length to solve the problem. Like question number 1, to answer the question number 2, student smoothly uses and modifies formula of tangent line two circles to determine the length of circle’s radius.

In problem number 3, the problem is given in the form word problem. To determine costs which is needed for the cultivation grass of baseball field using concept circle sector. It shows that student can identify the elements of the circle in everyday life. Based on students' answers, they first determine the area of two pieces of circle sector that is the area of BOC and AOD sector. After that, to determine the area which be want to be planted by grass, students calculate it by subtracting the area of BOC sector and the area of BOD sector. The last step, the cost of baseball field grass planting is determined by calculating the area that has been calculated previously with the cost of planting grass per square meter that has been known from the problem. At the time of the interview, students could explain well each step of their answers and students could also explain why they chosed to use that concept to solve the problem. Based on the result above can be seen that the students can solve all problems correctly so that the students with high self-efficacy tend to be interested in solving problems with varying level of difficulty and they are not easy to hopeless when they solve the mathematics problems [23]

### 3.2. Student with Moderate Self-Efficacy
Figures 4 and 5 show that student understands the problem well. Student can identify and write the information needed to solve the problem. In Figure 4, it shows that student is able to give answers regarding the given problem. The student can rewrite all informations needed to answer the question by using precise mathematics symbol. In addition, student is also able to translate the problem into the picture form and adds description and size to each element of the circle in accordance that has been known. At the time of the interview, the student was able explain well the meaning of each symbol which he wrote and he could show in picture about circle elements that are known and asked from the problem. From the students’ answers, it also appears that they understand well the concept used to solve the problem. They use the concept of arc circle. However, the answers given by the student is still less precise, because they directly use angle that known (45°) to determine the length of the TU arc. The picture which is made by student, show that m∠SOU = 45° does not match with length of the arc to be searched (TU). Actually first, student should find the large of angle that corresponds with TU arc by using the concept of straight angle.

According to the student's answer in figure 5 shows that there are some fundamental mistakes made by student. Actually, student understands how to determine length of the circle radius on tangent line of two circles, but there is still fundamental mistake made by the students. Example, in writing the formula \( r_1 + r_2 = \sqrt{p^2 - d^2} \) which should be \( r_1 + r_2 = \sqrt{p^2 - d^2} \). At the time of the interview, the student looked confused when the researcher asked about the large of angle used to calculate TU arc. He replied that he forgot, so he directly uses large of angle that has been known from the problem. It is in accordance with Pirie and Martin [25] that students actually have knowledge of concepts, but when faced with problems related to the concept, the knowledge is inaccessible quickly. Therefore, it is necessary to repeat again by the students about the basic concepts.

### 3.3. Student with Low Self-Efficacy

Figures 6 and 7 show that student can rewrite all informations which are needed to solve the by using mathematics symbols appropriately. At the time of interview, student also could explain the meaning of each symbol is written. It shows that student knows the appropriate symbols commonly used to represent the elements of the circle. However, when student was asked for to translate or represent the problem into the, picture they had difficulty. According to the problem, in problem number 1,
number 2, and number 3 respectively about the length of the circle arc, the tangent of two circles, and the area of sector circle, student can not represent the problem well into the picture. During the interview, student also could not properly show the elements of the circle associated with the problem. Based on student’ answer in problem number 1 indicate that the student has used concept of arc circle to solve the problem. Student directly used the large of SOU angle that has been known (45°) although SOU angle is not suitable with TU arc. However, when confirmed during the interview student could not explain the concept which was used. He argued that his answer was the result of cheating his friend’s work. This indicates the student does not really understand the problem. In line with a study that reveal that one of the characteristic of poor student’s mathematical communication ability is students can’t explain the concepts that they use to solve the problem and they can’t give precise reasons [9].

In problem number 2, student has written precise concept to determine length of the radius one of the circle by using tangent concept, but from the interview result, his answer also was result of cheating the work of his friend. He confused when he had to modify the formula of tangent’s two circles to determine the length of radius one of the circle. It indicates that student only focus on memorizing formula without understanding well when and how the formula and concept are used to solve the problem. In problem number 3, none of the students completed it. Based on the result of interview, student did not solve the problem because it was quite difficult and not the same as examples of problem ever given by teacher. In accordance with the research of Kitsantas, Chema and Ware research that students with low self-efficacy tend to have low math scores [21]. Students with low self-efficacy tend to be frustrated and easily hopeless when they fail and when they faced with a difficult problem [22].

4. Conclusion
Basen on the result and data analysis can be concluded that there is strong correlation between self-efficacy and student’s mathematical communication ability. Students with high self-efficacy can master all indicators of mathematical communication ability which are measured in this research. Students with moderate self-efficacy can only master two indicators, namely: ability to identify and write information needed in solving problems by using notation, symbol, or mathematical term and ability to translate the essay or word problem into the picture or sketch and create mathematical models. Students with low self-efficacy are only able to master the indicator of ability to identify and write the information needed in solving problems by using notation, symbol, or mathematical term.

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